

Anterior instrumentation for the treatment of pyogenic vertebral osteomyelitis of thoracic and lumbar spine

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Abstract Anterior radical debridement and bone grafting is popular in the treatment of pyogenic infection of the spine, but there remains great concern of placing instrumentation in the presence of infection because of the potentiality of infection recurrence after surgery. The objective of this study was to prospectively evaluate the efficacy and safety of anterior instrumentation in patients who underwent simultaneous anterior debridement and autogenous bone grafting for the treatment of pyogenic vertebral osteomyelitis. The series consisted of 22 consecutive patients who were treated with anterior debridement, interbody fusion with autogenous bone grafting and anterior instrumentation for pyogenic vertebral osteomyelitis of thoracic and lumbar spine. The patients were prospectively followed up for a minimum of 3 years (average 46.1 months; range 36–74 months). Data were obtained for assessing clinically the neurological function and pain and radiologically the spinal alignment and fusion progress as well as recurrence of the infection. All the patients experienced complete or significant relief of back pain with rapid improvement of neurological function. Kyphosis was improved with an average correction rate of 93.1% (range 84–100%). Solid fusion and healing of the infection was achieved in all the patients without any evidence of recurrent or residual infection. The study shows that combined with perioperative antibiotic regimen, anterior instrumentation is effective and safe in the treatment of pyogenic vertebral osteomyelitis of

thoracic and lumbar spine directly following radical debridement and autogenous bone grafting.

Keywords Pyogenic vertebral osteomyelitis · Spinal fusion · Anterior instrumentation

Introduction

Pyogenic vertebral osteomyelitis remains a challenge to spine surgeons since it may be associated with neurological deficit and other comorbidities. The introduction of modern antibiotic therapy has made it possible to successfully manage pyogenic vertebral osteomyelitis with conservative methods in most patients [6, 12, 18, 20, 23, 50]. However, cases with persistent infection, neurological compromise, significant instability with spinal deformity or unsuccessful conventional therapy often require surgical intervention [1, 3, 26, 39, 41, 47] although the indications of surgical management remains debated. Since Hong Kong procedure was introduced in the treatment of spinal tuberculosis, anterior radical debridement and grafting with or without supplemented instrumentation have become popular in the treatment of not only tuberculous but also pyogenic nontuberculous infection of the spine [9, 10, 13, 14, 27, 42, 52].

While surgical management of pyogenic vertebral osteomyelitis continues to evolve, significant controversy remains whenever a decision is made with regard to operative approaches and techniques [6]. The reported techniques of surgical treatment include anterior debridement and interbody fusion, posterior debridement and instrumentation, anterior debridement and interbody fusion combined with posterior instrumentation in single- or two-stage fashion. Despite the different surgical concepts,

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Table 1 Clinical data of all patients with pyogenic vertebral osteomyelitis

Patient	Involved region	No. of involved body levels	Duration of disease (months)	Duration of continuous intravenous antibiotic administration before surgery (weeks)	Blood/urine culture	Percutaneous biopsy culture	Organism	Antibiotic treatment		Follow-up period (months)
								Initial	After culture results obtained	
1	Thoracic	2	6	12	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	47
2	Lumbar	2	12	6	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	74
3	Lumbar	2	3	7	Negative			Cephalosporins	Cephalosporins	36
4	Lumbar	2	8	8	Positive			Cephalosporins	Cephalosporins	37
5	Thoracolumbar	2	10	4	Negative	Negative		Cephalosporins	Cephalosporins	42
6	Lumbar	2	8	4	Negative	Positive	<i>S. aureus</i>	Cephalosporins	Cephalosporins	38
7	Thoracic	2	2	8	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	47
8	Lumbar	2	4	6	Negative	Negative		Cephalosporins	Cephalosporins	36
9	Thoracolumbar	2	6	8	Positive		<i>S. aureus</i>	Cephalosporins	Vancomycin	48
10	Lumbar	2	10	4	Negative			Cephalosporins	Cephalosporins	47
11	Thoracic	2	4	12	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	60
12	Thoracolumbar	1	10	6	Negative	Negative		Cephalosporins	Cephalosporins	36
13	Thoracic	2	8	2	Negative			Cephalosporins	Cephalosporins	72
14	Thoracolumbar	2	5	5	Positive		<i>S. aureus</i>	Cephalosporins	Ampicillin-sulbactam	49
15	Thoracic	2	8	4	Negative			Cephalosporins	Cephalosporins	48
16	Thoracolumbar	2	4	4	Negative			Cephalosporins	Cephalosporins	61
17	Thoracic	2	3	8	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	38
18	Lumbar	2	4	6	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	48
19	Lumbar	2	9	4	Negative			Cephalosporins	Cephalosporins	43
20	Lumbar	1	6	6	Positive		<i>S. aureus</i>	Cephalosporins	Cephalosporins	36
21	Thoracolumbar	2	4	6	Negative	Negative		Cephalosporins	Cephalosporins	36
22	Thoracic	2	3	4	Negative			Cephalosporins	Cephalosporins	36

it is generally believed that the choice should be based upon whether the infectious and necrotic tissues could be thoroughly removed, whether the patients would tolerate the surgical intervention with relatively fewer complications, whether the spinal stability could be maintained or reconstructed primarily, and whether the surgery would provide the ideal environment for bony fusion.

Use of anterior instrumentation in the surgical treatment of pyogenic vertebral osteomyelitis has been infrequently reported [8]. There has been great concern of placing instrumentation in the presence of infection because of the potentiality of infection recurrence after surgery [31, 37, 48]. In the current study, the efficacy and safety of anterior instrumentation was prospectively evaluated, in patients who underwent simultaneous anterior debridement and autogenous bone grafting for pyogenic vertebral osteomyelitis of thoracic and lumbar spine, for at least 3 years after surgery.

Materials and methods

This study was approved by the institutional review board of our hospital before undertaken. Twenty-two consecutive

patients with pyogenic vertebral osteomyelitis of thoracic and lumbar spine were managed with anterior debridement, interbody fusion with autogenous bone grafting and anterior instrumentation (Table 1) in our hospital between January 1999 and June 2003. The age of the patients ranged from 28 to 80 years (average 46 years); 12 patients were male and 10 female. The duration of symptoms before admission ranged 2–10 months (average 6.2 months). All the 22 patients had back pain. Fever was present for a considerable time in 19 of the 22 patients with 11 above 38°C. The onset of disease, however, was gradual and insidious in all the patients but three who had high fever coming on suddenly. All the patients had significant weight loss. Eleven patients presented with varying degree of neurologic impairment in terms of weakness, and four of them had mild hypoesthesia below the neurological level of the lesion. Neurological status on submission graded C in 3 patients, graded D in 8 and graded E in 11 according to the Frankel scoring system. Sphincter disturbance was observed in 3 of the 11 patients with the duration from 1 to 3 months. None of the patients could ambulate because of pain and weakness.

Only 11 patients could be presumed for the source of the spinal infection despite careful diagnostic examination: 8

patients had a history of respiratory or urinary tract infection. All the patients had no recent (fewer than 12 months) nonspinal procedures or previous surgical interventions to the spine except one who had undergone a debridement for the vertebral osteomyelitis at the thoracolumbar junction through lateral extracavitary (costotransversectomy) approach a month prior to this surgery. None of these patients had undergone supplementary posterior instrumentation surgery before. The coexisting medical conditions included diabetes mellitus in two patients and malnourishment in seven.

All the patients underwent blood cultures and five had urine cultures done, but infectious organisms were isolated from blood cultures in only ten patients, of whom one had positive urine cultures as well. Laboratory examination revealed a leukocytosis in 18 of the 22 patients. The primary causative organism was *Staphylococcus aureus* in nine cases and *Bacillus coli* in one case. All the patients had elevation of erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP). Percutaneous biopsy of the affected vertebral bodies was performed on five patients posteriorly through a transpedicular approach under fluoroscopic or CT monitoring. Cultures of biopsy specimens were positive for *S. aureus* from only one of the five patients, but the diagnosis of pyogenic osteomyelitis was confirmed histologically in all of them although the results showed no bacterial growth in the other four.

The diagnosis was based upon clinical presentation, imaging findings and laboratory examination, and subsequently confirmed by histopathological analysis of specimens obtained during surgery. The indications for surgery included one or a combination of the following: intractable back pain, neurological compromise, gross kyphotic deformity associated with extensive destruction, and persistent infection that failed to respond to conservative treatment. All the patients were prescribed with continuous intravenous antibiotic therapy for at least 4 weeks before surgery except three, of whom two experienced neurological deterioration after 2 and 3 weeks of continuous intravenous antibiotic therapy, respectively, and the other one suffered progressive vertebral destruction with elevated body temperature and white blood cell counts at the third week of using antibiotic medication.

Anterior radical debridement, decompression and autogenous bone grafting were carried out in single-stage and -approach under general anaesthesia with endotracheal intubation. With patients were placed in the right lateral decubitus position, the lesions were approached through an intrapleural approach for the thoracic and thoracolumbar region and a retroperitoneal approach via a flank incision for the lumbar vertebrae. Corpectomies and discectomies were performed to remove all pus and necrotic tissue to healthy bleeding cancellous bone. Then, anterior fusion

was accomplished with bone strut autografts or titanium mesh cages (Pyramesh, Metronic Sofamor Danek, Memphis, TN, USA) wedged into the defect created after debridement. The autografts used were obtained from the resected ribs by thoracotomy or tricortical autografts from the iliac crest. In all the cases, anterior spinal plating was done using the titanium Z-plate instrumentation (Metronic Sofamor Danek, Memphis, TN, USA). The instrumentation extended one level above and one level below the affected vertebrae in all cases of this series. No posterior instrumentation was supplemented in any of these patients.

All the patients were initially treated with intravenous broad-spectrum cephalosporins, and then the antibiotic therapy was adjusted whenever organisms grown in cultures were identified and the sensitivities to antibiotics of these organisms were obtained (Table 1). These patients had received 2–12 weeks of continuous intravenous antibiotic therapy before surgery.

Follow-up examination was performed during the first year at 6 weeks, 3, 6, 9 months and 1 year. Subsequent follow-ups were at yearly intervals. Patients were followed for a minimum of 3 years (average 46.1 months; range 36–74 months). At each follow-up survey, they were assessed clinically for neurological function and pain and radiologically for spinal alignment and fusion progress. Neurological function was assessed according to the Frankel score, and pain was scored from 0 (no pain) to 10 (the worst imaginable pain) using a visual analog scale (VAS) system. Plain anteroposterior and lateral radiographs of the thoracolumbar spine were obtained at each visit, and they were compared with those made before surgery and immediately after surgery. Sagittal alignment was evaluated by measuring the sagittal angles with the Cobb method, and the results obtained at final follow-up was compared with the sagittal index (SI) as defined by Farcy et al. [16] Dynamic flexion–extension lateral radiograms were also taken to determine the fusion status 3, 6 and 9 months postoperatively. Successful fusion were defined as absence of local pain and tenderness over the site of fusion, no abnormal motion, no correction loss and hardware failure, presence of trabecular bone bridging between the grafts and the vertebrae, and no lucencies at the bone-cage interfaces when anterior reconstruction of the spine was made with the cages. Monitoring of laboratory parameters (white blood cell counts, ESR and CRP) was made regularly until these parameters returned to normal values and oral antibiotic drugs therapy was discontinued.

Results

The average duration of operation was 168 min (range 120–260 min), and the average intraoperative blood loss

was 1,152 mL (range 400–3,800 mL). There were no operative complications recorded.

Diagnosis was confirmed by histopathological examination of intraoperative biopsy in all patients, with the findings characterized by aggregates of inflammatory cells, erosions of trabecular bone, enlargement of haversian systems, and marrow changes such as a loss of normal marrow fat, and fibrosis and reactive bone formation. Tissue specimens obtained from the diseased spinal tissue at operation was sent for culture in all cases, but only three had positive cultures that were correlated with the organism discovered from blood (two cases) or biopsy specimens (one case) before surgery. Intravenous antibiotic medications were continued for at least 3 weeks (range 3–6 weeks) after surgery and followed by oral antibiotics for at least 4 weeks or until all laboratory parameters in terms of white blood cell counts, ESR and CRP returned to normal limits (range 4–10 weeks). Patients were allowed to sit on the first postoperative day, and were encouraged to stand and ambulate on the third postoperative day as their neurological status allowed. No cast immobilization was used, but two patients were immobilized in a rigid external orthosis for 12 and 16 weeks, respectively.

All the patients experienced immediate relief of their back pain on the first postoperative day with fever dropping after several days. Eighteen of them began standing and walking on the third to seven postoperative day, and the remaining three patients with Frankel grade C were able to ambulate between 2 and 4 weeks after surgery. No neurological deterioration after surgery was noted in any of the cases. All the ten patients with preoperative neurological deficit had complete recovery (grade E) within 1–6 months, except one with grade C had improvement by one level to grade D. The three patients who had their preoperative sphincter symptoms recovered completely. Sixteen of 21 patients were pain free at final follow-up visit. The remaining five reported back pain that was mild and intermittent (VAS 1–2) but different from their preoperative pain, and they did not require any form of medication for pain control.

There were no complications related to surgical intervention except mild to moderate donor site pain in eight patients at final follow-up, and no recurrence of infection was noted in any patient at the final follow-up. Solid bony fusion was achieved in all patients with the fusion time between 3 and 6 months (Figs. 1, 2). No patients showed evidence of failure of implants although mild subsidence of the cage was noted in three patients. Preoperative, immediately postoperative, and final Cobb angle was compared on serial radiographs. The preoperative kyphotic deformity was corrected from an average of 11.3° (range -10° to -27°) to an average of 5.5° (range -17° to -5°) immediately after surgery (Table 2). No statistical correction

loss ($>3^\circ$) at final follow-up was found in any of these cases with an average correction rate of 93.2% (range 84–100%) as compared with the SI. There was no difference of correction rate of deformity between the patients who underwent surgery with and without titanium cage.

Discussion

Because the pathoanatomy of pyogenic vertebral osteomyelitis is typically anterior to the neural contents, anterior operative approaches are usually preferred. An anterior approach allows radical debridement, direct decompression and reconstruction of anterior column. Patients with pyogenic vertebral osteomyelitis can be successfully treated with an anterior debridement and fusion and subsequent immobilization with casting or bracing [4, 12–14, 26, 33, 35, 43]. These patients usually need to be maintained in bed after surgery, and the duration of bedrest will depend upon the degree of stability achieved at operation. Therefore, addition of posterior instrumentation in a noncontaminated field seems to be a more logical choice of treatment modalities to avoid graft displacement and facilitate early rehabilitation [3, 5, 10, 11, 15, 19, 21, 27, 31, 36, 41, 46]. In some cases treated with posterior instrumentation, a cylindrical titanium cage filled with bone graft has been also used as an alternative to structural bone grafting [17, 25, 28, 29, 32, 36, 48]. The results showed that titanium mesh cages when supplemented with posterior instrumentation was effective and safe for pyogenic vertebral osteomyelitis, and offered a biomechanically stable support. However, the extent of the posterior instrumented fusion is commonly chosen two levels above and below the infected segments, and this may lead to the loss of more normal motion segments. Another argument against the combined anterior and posterior surgery is the risk of increased morbidity associated with prolonged anaesthesia and operation time, and additional blood loss and tissue damage. As major perioperative complications or deaths have been reported in some series, combined anterior and posterior surgery may be more dangerous to a patient who is medically unstable.

The preliminary success in titanium mesh cages used for pyogenic vertebral osteomyelitis has eradicated, at least partly, the fear that placement of metallic constructs in the area of infection would cause persistent or recurrent infection, so anterior plating following radical debridement and grafting may be the logical choice of surgical treatment modalities. Kostuik [30] described 79 patients treated with anterior spinal cord decompression, bone grafting and anterior instrumentation for different pathologies. Pyogenic infections were diagnosed in 15 of these patients and 2 had the rod/screw construct used for anterior instrumentation. Heary et al. [24] reported on a patient with rapid

Fig. 1 A 57-year-old woman was referred to our hospital with a 6-month history of progressively worsening back pain and episodic fever. Radiological studies showed T7–8 disc space destruction with adjacent vertebral body destruction and kyphotic deformity (a). MRI revealed the typical osteomyelitic changes in the T7 and T8 vertebral bodies along with the prevertebral abscess (b, c). Blood and urine cultures were negative. Through a left thoracotomy a T7 and T8 corpectomy was performed with radical debridement. Anterior plating was applied and the autogenous rib bone grafting done. Three months after operation, the X-rays showed the bony fusion. She remained pain-free at the final follow-up when radiographs showed satisfactory fusion (d, e). No recurrence of the disease was noted in this patient



progression of pyogenic vertebral osteomyelitis. After a surgical debridement and subsequent 4 weeks of intravenous antibiotic therapy, the patients underwent autogenous bone grafting and anterior plating. Since then, several series have been presented with patients undergoing anterior corpectomy and plate fixation [10, 15, 24, 30, 37, 38, 44, 48, 51], but the number of patients enrolled in these studies was relatively small and most of them were cervical cases.

Our study demonstrated that anterior instrumentation was effective in the treatment of patients with pyogenic vertebral osteomyelitis of thoracic and lumbar spine following anterior debridement and autogenous bone grafting. In this prospective series of 22 consecutive patients followed up for at least 3 years, satisfactory clinical and radiological outcomes were shown with no cases of recurrent infection. Solid fusion and healing of the infection was achieved in all the patients. The results of the current study also suggested that the immediate stabilization achieved by anterior plating with or without titanium cages in the surgical treatment of vertebral osteomyelitis

could provide better correction of sagittal alignment and faster fusion time with decreased postoperative complication rates, and avoid the necessity for prolonged external immobilization.

To the best of our knowledge, this is the largest single series in the literature reporting single-stage and -approach anterior-only instrumentation for pyogenic vertebral osteomyelitis (Table 3). In this study, the measured sagittal alignment significantly improved with an average correction rate of 93.1 (range 84–100%) and no significant correction loss ($>3^\circ$) at final follow-up was found in any patient. Only two patients were immobilized with external orthosis postoperatively. These results suggested the advantages of anterior-only instrumentation to reconstruct the stability of thoracic and lumbar spine when one or two vertebral bodies are removed. Although the posterior element was intact in all cases in this series, we believe that, based upon our experience and studies by other authors of thoracic and lumbar tumours or fractures treated with anterior instrumentation, such treatment of three-column

Fig. 2 This 74-year-old patient had a *Bacillus coli* urinary-tract infection and back pain for 3 months. Although intravenous antibiotics were given, she developed gradual weakness of the lower extremities (Frankel C) with the temperature persistent above 39°C. A CT scan of the thoracic spine revealed destruction of the T6 and T7 vertebral bodies (**a**), and MRI scan demonstrated osteomyelitis at T6 and T7 with pre- and paraspinal abscess (**b**, **c**). The patient underwent radical debridement, followed by the reconstruction using a titanium mesh cage filled with the crushed autograft rib bone and anterior plating. Back pain improved immediately after surgery with the temperature returned to normal on the third postoperative day. Her weakness was relieved. Solid bone fusion was identified at the final follow-up examination (**d**, **e**)

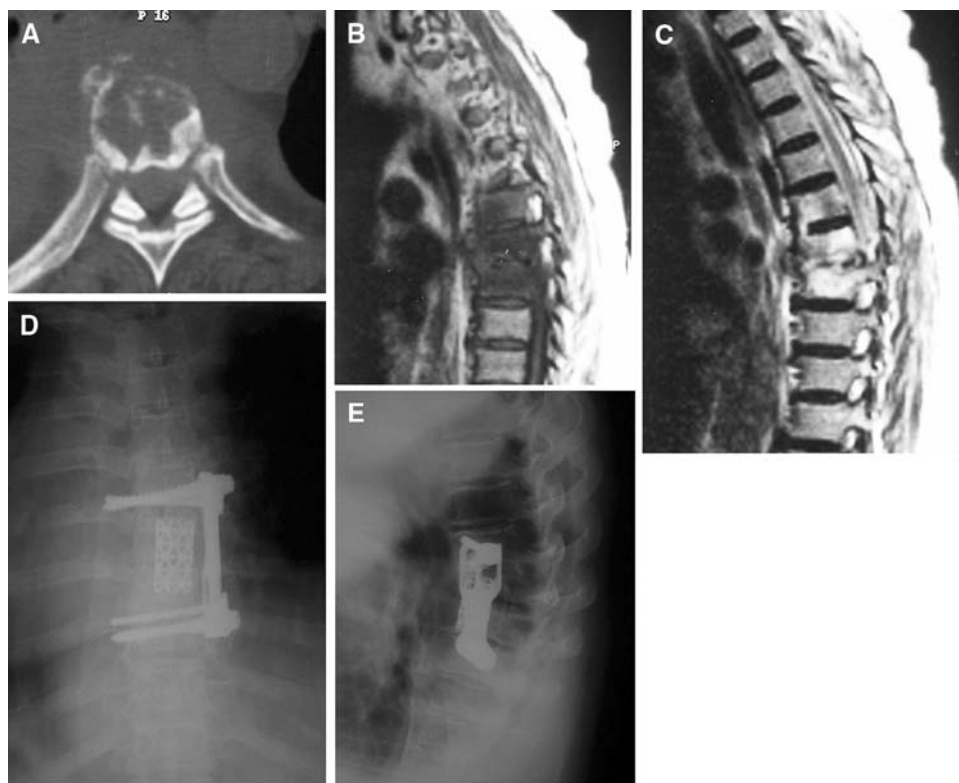


Table 2 Changes in kyphosis angle (°) in different regions

Region	Preoperative	Postoperative
Thoracic (<i>n</i> = 7)	15.5° (10° to 27°)	2.4° (0° to 5°)
Thoracolumbar (<i>n</i> = 5)	12.2° (−2° to 25°)	1.4° (−3° to 5°)
Lumbar (<i>n</i> = 10)	7.7° (−10° to 20°)	−10° (−17° to 2°)

involvement would be similar to ours in outcomes and the need for a posterior approach might be eliminated.

In contrast to previous retrospective studies, we followed up prospectively the 22 consecutive patients for a minimum of three years. While offering immediate stabilization and preventing graft dislodgement, anterior instrumentation following debridement and fusion did not lead to the persistence or recurrence of infection in the current series. The success of anterior instrumentation may be contributed to thoroughly debridement, effective antibiotic therapy, and stabilization of the spine. As there was no recurrence of infection after anterior instrumentation in any patients of this series, we believe that the primary spine stability provided by anterior instrumentation not only assist bony fusion but also promote control of infection.

The ample blood supply to the vertebral bodies and adequate soft tissue coverage of the anterior spine may also constitute the reason for the success of anterior instrumentation in the treatment of pyogenic vertebral osteomyelitis. This argument seems to be supported by the

Table 3 Summary of the literature reporting anterior-only instrumentation surgery for pyogenic vertebral osteomyelitis

References	No. of patients treated surgically		
	Total	Anterior instrumentation only	
		Cervical	Thoracic and lumbar
Kostuik [30]	12	0	2
Heary et al. [24]	1	1	0
Dietze et al. [10]	27	4	0
Faraj and Webb [15]	31	0	1
Rezai et al. [44]	39	8	1
Shad et al. [48]	5	4	0
Nather et al. [38]	12	1	1
Nakase et al. [37]	9	2	2
Woertgen et al. [51]	34	5	5
Current authors	22	0	22

study by Levi et al. [34] who retrospectively reviewed 452 consecutive patients treated with spinal instrumentation. The authors found that all the postoperative infections occurred in 17 (7.2%) patients after posterior spinal instrumentation procedures, whereas there were no infections after anterior instrumentation procedures regardless of spinal level. They related the infection after posterior instrumentation procedures to the extended surgical exposure during the posterior surgery, the large dead space created by instrumentation surgery, and the increased

operation time and blood loss. In another retrospective study of 850 spinal procedures [49], 21 of 22 infections occurred with posterior instrumentation although instrumentation was used in only three of the 276 anterior procedures.

Shad et al. [48] presented the possibility of delayed infection by identifying bacteria growth at the screw sites after removal of anterior cervical plate within 1 year of surgery in four asymptomatic patients. The bacterium found was different from the causative organism obtained from the primary surgery, thus indicating a new secondary infection. They recommended removal of implants placed in the infected region. However, we do not believe that their findings would inevitably lead to such conclusion. Whether the presence of the bacterium in the infected region is related to instrumentation or surgery without instrumentation needs to be further elucidated.

Titanium mesh cages have been shown to be effective for reconstructing a deficient anterior column after a corpectomy in the treatment of vertebral pyogenic osteomyelitis [17, 27, 28, 45, 48], by providing immediate spinal stability and improving sagittal balance, and thus facilitating bone healing. The use of titanium mesh cages supplemented with posterior segmental instrumentation has also been proved to be safe in preventing the recurrence of infection. Furthermore the cages can limit donor site complications associated with iliac bone graft harvesting. As animal experiments have shown the lower rate of infection with titanium alloy than with stainless steel [2, 40], the ideal biocompatibility of titanium may explain the satisfactory results of this series and would partly eliminate the concern of using metallic implants in the setting of infection. However, the results from the studies of relation between material biocompatibility and bacterial or cell adhesion and colonization on the material surface are inconsistent [7, 22].

In conclusion, anterior instrumentation is effective and safe in the treatment of patients with pyogenic vertebral osteomyelitis of thoracic and lumbar spine following anterior debridement and autogenous bone grafting. The results of this prospective study indicate that the presence of instrumentation anteriorly at the site of infection provides immediate stability of the spine by reconstruction of the anterior spine, and therefore improves and maintains the sagittal alignment of the spine and facilitates solid spinal fusion without increasing the risk of infection recurrence.

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